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Birdlife of Mickett Creek: factors influencing frequency of occurrence and detection

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Abstract

Over a five-year period 82 bird species were recorded during diurnal visits to the Mickett Creek area near Darwin. Frequently recorded species were generally those that were resident (hence present all year round), were moderately to highly abundant, and vocalised regularly. Species with loud or highly penetrating calls and vocally active species may have been recorded more often than other birds of similar abundance. Infrequently recorded species included seasonal visitors, particularly dry season migrants and birds associated with seasonal wetlands, and discreet species that are presumably resident but are rarely detected because of secretive habits and vocalisation characteristics. Nocturnal species were infrequently flushed during the day, but are known from the area from nocturnal surveys. Habitat types, seasonal distribution of water, food resources, and movement patterns of birds affect species composition at a local scale. It is concluded that numerous surveys over many years are required to obtain a comprehensive avifaunal species inventory for bushland sites in monsoonal northern Australia.

Introduction

Birds of the Top End of the Northern Territory comprise a diverse range of widely distributed species of the Torresian Zone, a small number of endemics, and a number of seasonal visitors (Morton & Brennan 1991). The avifauna of woodlands at a local scale consists partially of resident birds, supplemented with a range of visitors attracted to resources (Woinarski & Tidemann 1991; Franklin & Noske 1999), nomads, and species undergoing seasonal movements. Crawford (1972) provided the first comprehensive annotated list of birds of the Darwin region, including 254 species, based on five years of observations. Crawford noted the influence of seasonal movements, habitat selection, differences between subcoastal and inland avifaunal elements, and inter-annual population variability. Thompson (1978, 1988) described the common species of the Darwin suburbs and the Darwin area generally, including information on habitat and seasonality. The seasonal abundance of select groups has been described from a site near Darwin (Thompson 1982, 1984; McKean 1986), and there is some published material concerning food resources (Franklin & Noske 1999, 2000) and the role of vegetation type (Woinarski *et al.* 1988) on bird species

composition in monsoonal northern Australia. However, there is a paucity of site-specific survey data for areas near Darwin that examine frequency of occurrence in relation to the various factors that influence bird species presence and abundance.

In the course of preparing an inventory of species from a site, several factors determine how frequently a bird will be detected and recorded by an observer. At a fundamental level, the *presence* of a bird will be influenced by whether suitable habitat exists within the geographical distribution of the species (see Blakers *et al.* 1984; Barrett *et al.* 2003). Birds tend to occupy particular structural formations of vegetation, for example woodland or grassland. They may also be influenced by vegetation type, as delimited by the dominant plants, e.g. *Melaleuca* forest, eucalypt woodland. The extent and pattern of habitat type within the study site should, therefore, affect presence and abundance of bird species, and availability of resources within the habitat will also play a role (Wiens 1989). A subset of species will be present seasonally because of migratory or nomadic tendencies, and others will move locally. Even those species that are present throughout the year may be more or less active (and hence obvious), particularly in regard to calling, at various times of the year.

The second major consideration is the *detectability* of the species by an observer. Detectability is the probability that a bird will be recorded, and is dependent on whether the bird is audible or visible to the observer during the survey period. This is influenced by the behaviour of the individual bird, including the frequency and intensity (loudness) of calling, and whether it is obvious and thereby is detected. Many birds are secretive or cryptic, and may avoid the observer. Abundance will affect the probability of a species being recorded, and this will be influenced by aggregation, flocking and clumped distributions. The second component of detectability is the ability of the observer to discern and identify either the call (which may vary considerably) or the bird by sight. This is largely affected by familiarity with the avifauna of the region including knowledge of calls, but also the survey procedure adopted (Recher 1984; Saffer 2001). Lastly, time of day is likely to affect bird activity. It is generally accepted that birds are most active in the early morning and also (but less so) in the late afternoon. However, there are no published data in relation to the diurnal activity patterns of the birdlife of monsoonal northern Australia, and, at certain times (e.g. when it is cloudy) birds may be active at any time of day. The response to diurnal weather fluctuations and season in this regard is also not at all understood.

Here I provide frequency of occurrence information for bird species recorded from the Mickett Creek bushland site near Darwin, and examine some of the factors that influence the frequency with which the various components of the avifauna were observed. The study provides an insight into the species found in the area and serves as a basis for more systematic studies of functional ecological relationships, behaviour, breeding biology and habitat preferences.

Methods

The Mickett Creek site (12°24'39"S 130°56'37"E) is on the edge of suburban Darwin, Northern Territory, in the locality of Knuckey Lagoon, Shire of Litchfield. The site is on vacant Crown Land and is accessed via Brandt Road. It is part of an area of bushland, between the northern suburbs of Darwin and the city of Palmerston, which extends to the coast. Vehicular and walking tracks traverse the site, and several areas of bare soil and reduced vegetative cover exist as a result of past and on-going anthropogenic disturbance, including regular use by motorbike riders and off-road vehicles. To the north is the Mickett Creek Shooting Complex, which (aside from the cleared shooting ranges) has relatively undisturbed bushland, and to the west is Holmes Jungle. The site is approximately 7 km from the coast at Shoal Bay, but less than 4 km from mangrove estuarine habitats in the lower reaches of Mickett Creek.

In the monsoonal tropics the distribution of vegetation communities at a local scale is largely determined by position in the landscape and duration of inundation (Taylor & Dunlop 1985; Wilson & Bowman 1987; Cowie *et al.* 2000). The site comprises a freshwater low-lying section and associated savanna surroundings, and can be divided into three vegetation communities: upland savanna; mixed woodland intergrade habitats; and lowland seasonally wet or inundated drainages and damplands. The savanna open woodland is dominated by *Eucalyptus tetrodonta* and *Eucalyptus miniata* with *Erythrophleum chlorostachys* and the fully deciduous species *Terminalia ferdinandiana.* It is fairly typical of savanna woodlands (Brock 2001), with various shrubs and small trees including *Buchanania obovata, Livistona humilis, Planchonia careya* and *Acacia* spp. It is mapped as subcoastal open-forest (*E. miniata* and *E. tetrodonta* over *Sorghum*: Wilson *et al.*, 1990; Fox *et al.*, 2001) and is similar to the *Eucalyptus* open-forest of Wilson and Bowman (1986, 1987). In the seasonally wetter and less well-drained intergrade habitats, *Pandanus spiralis, Lophostemon lactifluus, Grevillea pteridifolia* and *Petalostigma pubescens* are more prevalent. The vegetation corresponds to the *Pandanus/Grevillea* and *Lophostemon/Eucalyptus* mixed open-forest of Wilson and Bowman (1987), and the mixed forest habitat of Crawford (1972). Low-lying seasonal creek and dampland habitats support *Carallia brachiata, Banksia dentata, Pandanus spiralis* and scattered *Corymbia polycarpa. Grevillea pteridifolia* generally occurs in mixed associations, and *Melaleuca viridiflora* dominates in seasonally inundated sites where it may occur as monospecific stands. Sedges and herbs grow in the wetter areas, with some patches dominated by *Dapsilanthus spathaceus,* and aquatics are evident in the wet season. Vines are obvious in the early wet season and mistletoe occurs particularly on *Melaleuca* spp. and *Grevillea pteridifolia.* Important flowering species (Franklin & Noske 2000) include *E. miniata, E.tetrodonta, C. polycarpa, G. pteridifolia* and *Melaleuca* spp.

Portions of the low-lying, seasonally inundated areas are natural regeneration from sand mining in the late 1970s and into the 1980s. Much of the habitat dominated by *Melaleuca viridiflora* appears to be regrowth. *Carallia brachiata* is becoming dominant in some low-lying regrowth patches, and a formation approaching a low closed-forest

has developed. In drier areas *Calytrix exstipulata* is characteristic of regeneration. Some soil expanses in heavily used areas remain devoid of vegetation. Of the invasive plant species at the site the most widespread is Perennial Mission Grass *Pennisetum pedicellatum* which is patchy in places and dominant in others, but in general is absent from wetter areas.

The environment in the wet and dry season is strongly contrasting. During the wet there is significant inundation of low-lying areas, creeks form and water flows. Flows diminish in the first part of the dry season (May to July) and all surface water usually disappears by September. Unusually for an area of bushland close to the city, the site was unburnt in most years. However, much of the upper savanna portion was burnt in the late dry season of 2008, and a patch of intergrade vegetation was burnt in July 2003.

Visits to the Mickett Creek area were initiated in May 2003, although not for the specific purpose of recording birds. A period was spent gaining familiarity with bird calls and becoming acquainted with the layout of the study area prior to keeping records. From January 2004 to August 2009 birds were recorded during diurnal visits to the site on 60 occasions. The site has been visited on numerous other occasions, particularly at night, but frequency data were included only where dedicated records were kept and birding was a focus of the visit. The survey procedure involved traversing the area on foot, using the network of tracks but also involving regular forays into the bush. Although a defined route was not followed, the portion of the site surveyed most frequently was approximately five hectares in area. In various instances exploratory excursions were made to new parts of the site. The aim during each visit was to record all species encountered. Although birds were often seen, in the great majority of cases birds were identified on the basis of calls. Unusual calls or unknown calls were investigated and the birds identified by sight.

Waterbirds that occur at nearby Knuckeys Lagoon that were observed overhead (e.g. Brolga *Grus rubicunda*), or that were heard as they passed over the site (e.g. Wandering Whistling-Duck *Dendrocygna arcuata*), were not included in the list for the site. Other birds seen overhead including lorikeets, diurnal birds of prey, and all passerines (including White-breasted Woodswallow and Tree Martin) were incorporated on the basis that they utilise the habitat either directly or while foraging overhead. Other species that were included were waterbirds using seasonally inundated areas, and Magpie Goose that were roosting in trees. The frequency data is based on the 60 diurnal surveys. Additional, incidental species recorded at other times have been noted in Table 1.

The average duration of visits was 70 minutes, and visits varied from 40 to 140 minutes. Most surveys were 60 ± 15 minutes. Slightly over half of the visits were in the morning (start time before 1000 hours), 30% were in the middle of the day (1000-1630), and the remainder were in the afternoon (1700 onward), with some of these last surveys continuing until dark. Visits were made in all months of the year (although

spread over the five years), with from three to seven visits per month, and most months having four or five visits.

Table 1. Bird species, frequency of observation, and habitat use at the Mickett Creek study site. Frequency (F) is the number of visits (out of 60) on which the species was recorded during diurnal surveys (- = incidental record). Species that had been recorded by 20 and 40 visits are indicated with an X. Habitat: S = savanna; I = mixed woodland (intergrade); and D = low-lying drainages and damplands. Other: N = recorded also during nocturnal surveys; n = flushed at night; o = observed overhead or in passage; and * indicates a nesting record. The family sequence follows Christidis and Boles (1994); names have been updated according to Christidis and Boles (2008).

Common Name *Species*	20	40	F	Habitat	Other
Non-Passerines					
Brown Quail *Coturnix ypsilophora*	X	X	2	S	
Magpie Goose *Anseranas semipalmata*		X	4	SD	N o
Radjah Shelduck *Tadorna radjah*	X	X	13	D	
Green Pygmy-goose *Nettapus pulchellus*			-	D	
Straw-necked Ibis *Threskiornis spinicollis*		X	1	D	
White-bellied Sea Eagle *Haliaeetus leucogaster*		X	2	D	
Whistling Kite *Haliastur sphenurus*	X	X	18	SID	
Black Kite *Milvus migrans*	X	X	10	SID	o
Black-breasted Buzzard *Hamirostra melanosternon*		X	1	S	o
Letter-winged Kite *Elanus scriptus*			1	S	o
Brown Goshawk *Accipiter fasciatus*		X	2	SI	
Collared Sparrowhawk *Accipiter cirrhocephalus*		X	1	S	
Common Greenshank *Tringa nebularia*		X	3	D	
Bush Stone-curlew *Esacus magnirostris*	X	X	3	SD	N
Masked Lapwing *Vanellus miles*	X	X	3	D	
Bar-shouldered Dove *Geopelia humeralis*	X	X	43	SID	n
Peaceful Dove *Geopelia striata*	X	X	51	SID	n
Diamond Dove *Geopelia cuneata*			1	S	
Pied Imperial Pigeon *Ducula bicolor*	X	X	1	D	
Red-tailed Black Cockatoo *Calyptorhynchus banksii*	X	X	26	SI	
Sulphur-crested Cockatoo *Cacatua galerita*	X	X	27	SID	
Little Corella *Cacatua sanguinea*	X	X	12	SID	
Red-winged Parrot *Aprosmictus erythropterus*	X	X	26	SI	
Northern Rosella *Platycercus venustus*	X	X	1	S	
Rainbow Lorikeet *Trichoglossus haematodus*	X	X	48	SID	o
Varied Lorikeet *Psitteuteles versicolor*	X	X	7	S	o
Pheasant Coucal *Centropus phasianinus*	X	X	12	SID	
Eastern Koel *Eudynamys orientalis*		X	7	ID	
Brush Cuckoo *Cacomantis variolosus*	X	X	14	SID	
Barking Owl *Ninox connivens*			2	D	N
Tawny Frogmouth *Podargus strigoides*		X	2	SID	N
Large-tailed Nightjar *Caprimulgus macrurus*			-	D	N
Blue-winged Kookaburra *Dacelo leachii*	X	X	29	SID	
Forest Kingfisher *Todiramphus macleayii*	X	X	38	ID	
Sacred Kingfisher *Todiramphus sanctus*		X	1	S	

Table 1 continued

Common Name *Species*	20	40	F	Habitat	Other
Rainbow Bee-eater *Merops ornatus*	X	X	45	SD	*
Dollarbird *Eurystomus orientalis*	X	X	14	SID	
Passerines					
Red-backed Fairy-wren *Malurus melanocephalus*	X	X	35	SI	
Weebill *Smicrornis brevirostris*	X	X	51	S	
Striated Pardalote *Pardalotus striatus*	X	X	37	SID	*
White-throated Gerygone *Gerygone albogularis*	X	X	3	SI	
Little Friarbird *Philemon citreogularis*	X	X	18	SID	
Silver-crowned Friarbird *Philemon argenticeps*	X	X	15	SID	
Helmeted Friarbird *Philemon buceroides*		X	2	ID	
Blue-faced Honeyeater *Entomyzon cyanotis*	X	X	11	SI	
White-throated Honeyeater *Melithreptus albogularis*	X	X	48	SI	
White-gaped Honeyeater *Lichenostomus unicolor*	X	X	45	SID	
Rufous-banded Honeyeater *Conopophila albogularis*	X	X	25	DI	*
Yellow-throated Miner *Manorina flavigula*	X	X	3	S	
Bar-breasted Honeyeater *Ramsayornis fasciatus*	X	X	4	D	
Brown Honeyeater *Lichmera indistincta*	X	X	45	SID	
Dusky Honeyeater *Myzomela obscura*			5	ID	
Banded Honeyeater *Cissomela pectoralis*			1	D	
Lemon-bellied Flycatcher *Microeca flavigaster*	X	X	46	ID	*
Grey-crowned Babbler *Pomatostomus temporalis*	X	X	47	SID	
Rufous Whistler *Pachycephala rufiventris*			1	S	
Grey Whistler *Pachycephala simplex*			1	D	
Spangled Drongo *Dicrurus bracteatus*	X	X	8	ID	
Magpie-lark *Grallina cyanoleuca*	X	X	21	SD	
Leaden Flycatcher *Myiagra rubecula*	X	X	7	SD	
Willie Wagtail *Rhipidura leucophrys*		X	2	ID	
Northern Fantail *Rhipidura rufiventris*	X	X	11	ID	
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	X	X	5	S	
White-bellied Cuckoo-shrike *Coracina papuensis*	X	X	50	SI	
Varied Triller *Lalage leucomela*	X	X	10	ID	
White-winged Triller *Lalage sueurii*			2	ID	
Figbird *Sphecotheres viridis*	X	X	4	SI	
Yellow Oriole *Oriolus flavocinctus*	X	X	31	SID	
Olive-backed Oriole *Oriolus sagittatus*	X	X	3	SI	
White-breasted Woodswallow *Artamus leucorhynchus*	X	X	17	SID	o
Little Woodswallow *Artamus minor*			1	D	
Pied Butcherbird *Cracticus nigrogularis*	X	X	5	SI	
Grey Butcherbird *Cracticus torquatus*	X	X	27	S	
Torresian Crow *Corvus orru*	X	X	33	SID	
Great Bowerbird *Ptilonorhynchus nuchalis*			3	SI	
Chestnut-breasted Mannikin *Lonchura castaneothorax*			1	D	
Long-tailed Finch *Poephila acuticauda*	X	X	27	D	*
Masked Finch *Poephila personata*		X	9	D	
Double-barred Finch *Taeniopygia bichenovii*	X	X	39	SID	*
Crimson Finch *Neochmia phaeton*	X	X	7	D	
Mistletoebird *Dicaeum hirundinaceum*	X	X	39	SID	
Tree Martin *Petrochelidon nigricans*		X	4	SD	o

Results

A total of 82 species was recorded from the site after 60 visits, including 45 passerines and 37 non-passerines (Table 1). The number of species recorded was 48, 55, 69 and 80 (two additional species were recorded incidentally) after 12, 20, 40 and 60 visits respectively. The number of species continued to increase gradually after 30 visits (Figure 1). A full list of species recorded from the site with current scientific names is provided in Table 1.

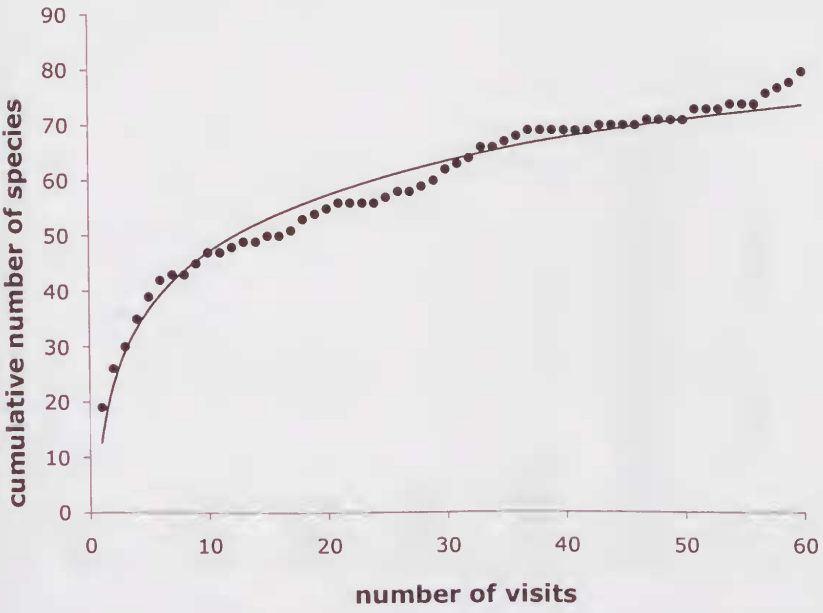

Figure 1. Species accumulation curve (points) for bird species recorded at Mickett Creek. The logarithmic curve has the form $y = 14.95\ ln\ (x) + 12.63$.

The number of species recorded during a visit ranged from 11 to 36, the average number recorded was 20 and the median was 19. On 15 occasions, 25 or more species were recorded; these surveys were generally in the morning (start time before 0830 h) and were always (with one exception) of more than an hour duration. Families represented by the greatest number of species (in parentheses) were the honeyeaters (Meliphagidae 12), diurnal raptors (Accipitridae 7), finches (Passeridae 5), pigeons and doves (Columbidae 4), and parrots (Cacatuidae 3 and Psittacidae 4). Five waterbirds and four nocturnal species were recorded.

After 60 visits, 11 species (4 non-passerines and 7 passerines) had been recorded on 40 or more occasions: Bar-shouldered Dove, Peaceful Dove, Rainbow Lorikeet, Rainbow Bee-eater, Weebill, White-throated Honeyeater, White-gaped Honeyeater, Brown Honeyeater, Lemon-bellied Flycatcher, Grey-crowned Babbler and White-bellied Cuckoo-shrike (Table 1). These were amongst the most regularly recorded species at 12, 20 and 40 visits, and species composition of the most frequently recorded species changed little over time. In all, 18 species can be categorised as common (recorded on 31 or more occasions) and 21 species as moderately common (11-30 occasions; Table 1). The majority of species were observed on ten or fewer occasions (Figure 2).

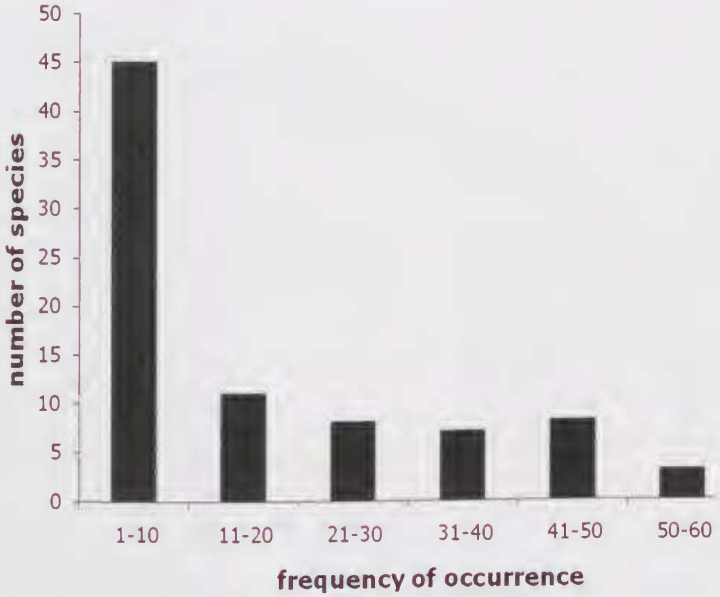

Figure 2. Frequency of occurrence of bird species at Mickett Creek after 60 visits.

Infrequently recorded species included several raptors and a mix of other irregular visitors to the site (Table 2). Three waterbirds were infrequent wet season visitors and Magpie Goose was observed on four occasions. Green Pygmy-goose was an incidental record. Six species are infrequent dry season visitors to the location (Table 2), and in addition Black-faced Cuckoo-shrike and Tree Martin were recorded on five and four occasions respectively. Several nocturnal species have been flushed infrequently during diurnal transects, and Large-tailed Nightjar was recorded only at night (Table 1).

Table 2. Infrequently recorded bird species (recorded three times or less during diurnal surveys) including seasonal visitors to the Mickett Creek locality and nocturnal species. Refer to Table 1 for frequency of observation. Status is based on seasonality of records from the site and information in Crawford (1972), Press *et al.* (1995), and Noske and Brennan (2002).

Resident or nomad	**Dry season visitor**
Brown Quail	Straw-necked Ibis
White-bellied Sea-Eagle	Diamond Dove
Black-breasted Buzzard	Sacred Kingfisher
Letter-winged Kite	White-winged Triller
Brown Goshawk	Olive-backed Oriole
Collared Sparrowhawk	Little Woodswallow
Masked Lapwing	
Northern Rosella	**Wet season visitor**
White-throated Gerygone	Green Pygmy-goose
Helmeted Friarbird	Common Greenshank
Yellow-throated Miner	Pied Imperial Pigeon
Banded Honeyeater	
Rufous Whistler	**Nocturnal species**
Grey Whistler	Bush Stone-curlew
Willie Wagtail	Barking Owl
Great Bowerbird	Tawny Frogmouth
Chestnut-breasted Mannikin	Large-tailed Nightjar

Discussion

Approximately a third of the bird species known from the Darwin region (Crawford 1972; Thompson 1978), over a quarter of the species recorded from Kakadu (Press *et al.* 1995), and approximately half of the species known from Litchfield National Park (Griffiths *et al.* 1997) were recorded from the Mickett Creek site. The greater area and diversity of habitats, including escarpments, coastal habitats and extensive freshwater wetlands, support a range of additional species in the other areas (Morton & Brennan 1991; Press *et al.* 1995). With the notable absence of Partridge Pigeon *Geophaps smithii*, bird species were similar to the 44 species recorded from five or more quadrats at Litchfield National Park (Woinarski *et al.* 2004). The forest and woodland birds are similar to those recorded by Woinarski *et al.* (1988) at nearby Howard's Peninsula. In contrast, the site supports relatively few of the birds associated with monsoon forest habitats. For example, Orange-footed Scrubfowl *Megapodius reinwardt,* Rainbow Pitta *Pitta iris* and Green-backed Gerygone *Gerygone chloronotus* were not present, and Grey Whistler was recorded only once. Figbird and Pied Imperial Pigeon were infrequently recorded, but are common in Darwin suburbs (Thompson 1978; pers. obs.) where tropical vegetation in well-watered gardens promotes flowering trees and fruiting palms. Species common both at Mickett Creek and in the suburbs of Darwin included

White-gaped Honeyeater, Rufous-banded Honeyeater, Double-barred Finch and Bar-shouldered Dove. Common grassland birds (e.g. Golden-headed Cisticola *Cisticola exilis*) were not observed, although potentially suitable habitat exists in the lower portions of the site during the wet season.

The most frequently recorded species, and indeed most of the species that were recorded on greater than 50% of visits (18 species, or 22% of the total; Table 1) were generally resident (Crawford 1972; McKean 1986; Thompson 1988; this study), moderately to highly abundant, and vocalise regularly. The relatively few nesting records were all of common or moderately common species (Table 1). In species rich families (raptors, parrots, finches, honeyeaters) there were usually one or two common species, while others were irregularly recorded, suggesting that these groups comprise both resident and visiting species.

Plant species and vegetation structure are determining features of the environment of birds (Macarthur & Macarthur 1961; Recher 1969; Ford 1989). Many birds of tropical northern Australia have wide habitat preferences (Morton & Brennan 1991), and utilise a range of foraging heights (Brooker *et al.* 1990). While most species utilised more than one habitat at the site, many were partially restricted to savanna or lowland areas. Typical savanna birds included Weebill, White-throated Honeyeater, White-bellied Cuckoo-shrike, Red-backed Fairy-wren, Grey Butcherbird and Red-winged Parrot. Lemon-bellied Flycatcher was abundant in patches of *Melaleuca* swamp. The vegetation in the wetter parts of the site is reverting to monsoon forest, and supports Yellow Oriole, Spangled Drongo, Rufous-banded Honeyeater, Varied Triller and Large-tailed Nightjar. Enhanced plant diversity and greater structural diversity of mesic habitats leads to greater avifaunal diversity (Noske & Brennan 2002), and may facilitate the survival of additional forest species in the future.

Food (particularly nectar) availability is known to enhance diversity (Ford 1989; Woinarski & Tidemann 1991) and local abundance (Franklin & Noske 1999) of birds in savanna environments. Major attractants in the area were the blossom of *Grevillea pteridifolia* (Friarbirds, small honeyeaters), *Eucalyptus miniata* (Rainbow Lorikeets and honeyeaters) and *Melaleuca viridiflora* (Rainbow Lorikeet, Friarbirds, small honeyeaters). There is a range of nectarivores in monsoonal northern Australia (Franklin & Noske 2000), and a diversity of flowering plants with potential to provide nectar sources throughout the year, but with a peak in the dry season (Franklin & Noske 1999; Brady 2009). Some species were regularly observed at blossom (e.g. Dusky Honeyeater, Brown Honeyeater), but probably all observed nectarivores are insectivorous to some extent. Mistletoe flowers and fruit are important to the Mistletoebird and were accessed by some of the honeyeaters.

Waterbirds, including Radjah Shelduck, Greenshank and Green Pygmy-goose, were occasionally attracted to temporary wetland habitats. A juvenile Sea-Eagle was also recorded in one year near a seasonally inundated lagoon. Finches tended to be more noticeable in the dry season, and as the water receded, they sought out remnant pools.

Long-tailed Finch, Masked Finch, Crimson Finch and Chestnut-breasted Mannikin were mainly recorded adjacent to water. Crawford (1972) noted a number of bushbird species that are more common, or only found, near water; proximity to water may partially explain the regular occurrence of Forest Kingfisher at the site.

Several species were seasonal visitors to the site and the Top End (Crawford 1972; Thompson 1978; Press *et al.* 1995). These species were recorded less frequently than most resident birds (Table 2). Eastern (Common) Koel is absent from the Darwin region in the dry season (Thompson 1982) and was relatively infrequent at Mickett Creek. Dollarbird is a fairly regular migrant (Thompson 1984) and was recorded in most years, being noticeable particularly in the buildup. Rainbow Bee-eater is a partial migrant, a species in which some birds are resident but others migrate (Chan 2001). This species was observed nesting in August, similar to other locations in Darwin (pers. obs.). Thompson (1984) noted a dry season peak in abundance of the Rainbow Bee-eater, possibly due to the presence of wintering birds from southern Australia, where they are strictly summer visitors. Some migratory species may consist of several sub-populations, including intracontinental migrants, overwater migrants to New Guinea and Indonesia (Beehler *et al.* 1986), and birds resident in northern Australia.

Dry season visitors including Black-faced Cuckoo-shrike and White-winged Triller (McKean 1986), Tree Martin and Little Woodswallow were recorded infrequently (Table 2). Seasonal reversal of prevailing wind direction may be an important factor in movement of birds to and from the tropical north. Black-faced Cuckoo-shrike, White-winged Triller, Tree Martin, Black Kite and White-breasted Woodswallow move from inland and may reach the coast or further afield, including southern New Guinea (Blakers *et al.* 1984; McKean 1986). Diamond Dove and Yellow-throated Miner are comparatively rare near the coast, but are relatively common in the southern half of Darwin region (Crawford 1972), and occur all year at Coomalie (R. Noske, pers. comm.). This could be regarded as movement to better-watered northern regions in the dry season, but Crawford (1979) viewed this phenomenon as a wet season migration from Darwin region due to 'improvements in conditions in the interior'. The arrival and departure dates of migrants are variable between years (Crawford 1972; Thompson 1982), and factors that induce migratory and nomadic movements in Australian arid zone and savanna birds remain poorly understood.

Calling associated with breeding or other seasonal activity means that some, and possibly all species are more likely to be detected at certain times of year. The Brush Cuckoo is particularly vocal in the wet season but is present throughout the year (Thompson 1982). Yellow Oriole tends to be more vocal during the buildup, and Striated Pardalote is more vocally active in the dry season when it constructs burrows to breed. Crawford (1972) noted that the Striated Pardalote makes a soft trill call in the wet, when it is much less conspicuous. It is difficult to ascertain if this species is a seasonal visitor or quiet resident. This is one of several species that are assumed to be

resident, but when they are vocally inactive they may easily be missed. There is a desperate need for studies to ascertain if species such as these are indeed sedentary.

Calling activity is dependent on time of day (Keast 1994), and this may affect the number of species recorded during a survey. Some species call early in the morning (e.g. Blue-winged Kookaburra), most call more frequently in the morning as part of the dawn chorus (e.g. Brown Honeyeater, White-gaped Honeyeater, Lemon-bellied Flycatcher, Bar-shouldered Dove, etc.), and some species call throughout the day (e.g. Weebill, White-throated Honeyeater, Brown Honeyeater). There is also generally a late afternoon peak. Further research is required to determine how temporal patterns of calling activity affect species recorded during (often brief) avifauna surveys. During rainy weather or in windy conditions, few species were recorded because activity and calling is reduced or ceases and birds are less conspicuous.

Visibility to an observer and characteristics of the call, including both audibility and regularity of calling, will influence the likelihood of detection of a bird species. Detailed knowledge of calls is important (Remsen 1994), especially where a species produces different types of vocalisations (e.g. juvenile, territorial, alarm and contact calls). Preliminary investigations to ensure familiarity with the bird calls at a site should be carried out prior to initiating detailed surveys. Birds with loud or highly penetrating calls (including Pheasant Coucal, Blue-winged Kookaburra, Red-tailed Black Cockatoo, Sulphur-crested Cockatoo, Bush Stone-curlew and Yellow Oriole) can be heard from a distance, so that they are more likely to be detected. In contrast, Leaden Flycatcher, Dusky Honeyeater, Bar-breasted Honeyeater, Red-backed Fairy-wren and Brown Goshawk can be very discreet. Nocturnal species were observed opportunistically at night, but were flushed rarely or not at all during the day; their cryptic plumage and immobility may often mean that they are not recorded although they are present.

After five years new bird species were still being added periodically to the Mickett Creek list (Figure 1), and it is doubtful whether all species have been recorded from the site. Indeed, nine new species were added in the last year of observations. The high proportion of rarely recorded species resulted in a long upward slope to the asymptote (Thompson & Withers 2003), and is suggestive of a variety of immigrant and transitory species visiting the area (Pielou 1977, p.289). Extrapolation of a logarithmic fit to the species accumulation data (generated in Excel; $r^2 = 0.96$) indicates that the accumulated total after 200 visits would approach 92 species. Based on the Chao 1 method (cited by Colwell & Coddington 1994), which incorporates the contribution of rarely recorded species, the calculated lower bound is 96 species. Numerous surveys over many years are required to obtain a comprehensive species inventory of all core and wandering species, particularly in tropical environments (Parker 1991; Remsen 1994). The majority of species were recorded on fewer than ten occasions, and 13 species were recorded only once. This underlines the importance of long-term studies of avifaunal communities. The addition of alternative methods for

censusing birds, (e.g. mist-netting and playback), would likely further increase the total for the area (Parker 1991).

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The Leaden Flycatcher (female illustrated) was a less common inhabitat of savannas and drainage lines at Mickett Creek. (Con Foley)

The Diamond Dove was a rare, dry season visitor to savanna habitat at Mickett Creek. (Con Foley)